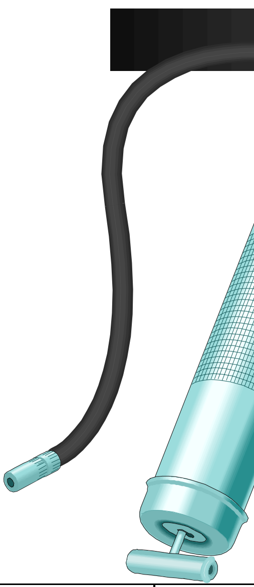
October 2002

MAINTENANCE BULLETIN



Alfa Company

Page	Contents

Construction Battalion Center
1000 23 rd Avenue
Building 1000
Port Hueneme, CA. 93043-4410
mailto:hillpm@cbchue.navfac.navy.mil

UNDERSTANDING BRAKE SHOE WEAR PATTERNS

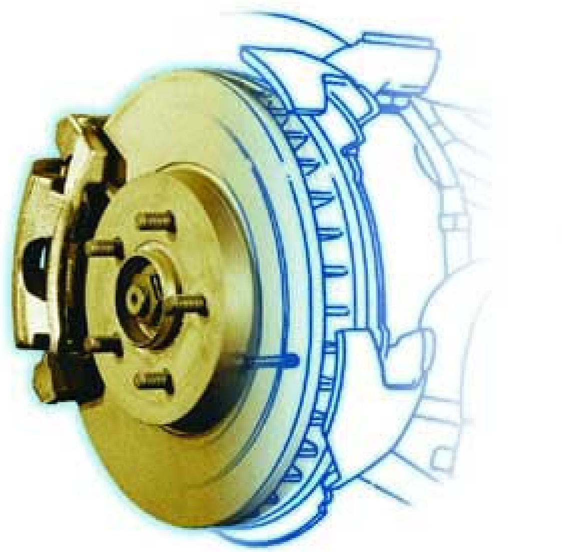
Brake shoes, and the friction material on them, are designed to wear evenly. When removing them from a vehicle for a brake friction reline, it is important to learn to "read" the old shoes before discarding them to the core bin. Brake shoe wear tells a story. That story is important to understanding what is needed to bring the vehicle's brake system back to its original healthy status.

<u>Brake systems that are unhealthy cause rapid wear and overheating!!!</u>

The friction material on the brake shoe should wear evenly around the entire circumference of the brake assembly. They also should wear evenly from the inboard side to the outboard side. If they have not worn this way, there is a problem in the system that needs to be corrected, or the same thing will happen to the new friction being installed. Inspect all linings for the following conditions:

- Shoes showing more wear at the inboard or outboard side, rather than wear that is uniform reveal <u>tapered wear</u>. Worn anchor pins, holes and bushings, or outer S-cam bushings can allow applied force to push the shoes to one side, resulting in tapered lining wear. This condition also is found with outer edge grinding on the brake shoe. This is caused by the brake shoe tracking out of proper alignment due to worn parts. Re-using shoe rollers and anchor pins, therefore, is never recommended.
- <u>Unequal lining wear</u> between the leading and trailing ends of a shoe are the result of weak return springs, worn outer S-cam bushings, or an out-of-arc brake shoe. Attempting to adjust a brake with any of these conditions will result in dragging and high contact pressure at one spot of the lining. This leads to rapid lining wear and heat damage to the brake drum.
- <u>Lining cracking</u> indicates that the lining may be loose on the brake shoe. A shoe that is out of arc, or has rust buildup on the shoe surface or improper riveting can cause this. When replacing the shoes, make sure that the lining is tight and follows the contour of the brake shoe. Always check a replacement shoe's dimensions. Do not assume that it is OK just because it's got new lining. Remember that bargain products are likely to give you more trouble than you bargained for; so insure that the proper lining for the job is being used for the job at hand.

If the linings are contaminated with grease or oil, correct the cause of that contamination before relining the vehicle. The problem is almost always a leaking oil seal, too much grease on a grease-type wheel bearing or camshaft bushing, or careless handling. Never use a lining that has been contaminated, as it will result in brake imbalance, and loss of performance and safe stopping. <u>Never clean off this type of problem and use the new lining!</u>
Professional results are obtained by examination of the friction material wear patterns!



Back in the 1970s, when cars and trucks with disc brakes first began appearing in service bays in numbers, servicing brake rotors was a relatively simple job. Most vehicles in your bays back then were from the Big Three in Detroit, which meant they had rear-wheel drive: discs on the front only and brake rotors that were integral with the hub.

In those days, resurfacing rotors was a regular part of every brake job. They were easily removed from the spindle after removing the dust cap, cotter pin and castle nut. After removing the wheel bearings, the rotor was mounted on the brake lathe arbor. The lathe's adapters used the hub's wheel bearing races to locate the rotor on the arbor, and in most cases, whatever runout that was in the rotor while on the vehicle was duplicated on the lathe. The rotor was machined on the lathe, and runout was usually within specifications when the rotor was reinstalled on the spindle. The rotor also could be turned without worrying much about surface finish, since the asbestos brake pads of the day were tolerant of rough finishes.

Because an on-car brake lathe resurfaces a rotor on its normal mounting, combined hub and rotor 'stacked" runout can be minimized.

Those brake pads also were easy on rotors. That fact along with the rotor's generous dimensions allowed a brake rotor to be resurfaced several times. Unless the customer drove the vehicle until the rivets or backing plate left deep scores, it was not uncommon for rotors to last for most of the life of the vehicle.

After the rotors were turned, it was just a matter of repacking the wheel bearings and installing a set of pads, and the front brakes were good for another 30,000 to 40,000 miles.

Complications

During the past three decades, however, changes in vehicle design and materials have directly and indirectly complicated brake rotor service.

The move to front-wheel and four-wheel drive vehicles, as well as the increased use of rear-wheel disc brakes, has made rotor removal more difficult and time-consuming on many vehicles. On some front-wheel drive vehicles, the entire knuckle must be removed from the vehicle and the rotor/hub assembly pressed from the knuckle, with reassembly usually requiring new bearings.

Even the easily removed non-integral rotor 'hats' present their own challenge. Because these rotors are machined separately from the hub, care must be taken during rotor setup prior to resurfacing if a traditional bench brake lathe is used, or lateral runout can be excessive when the rotor is reinstalled on the hub.

The quest by the OEMs to reduce vehicle weight, increase fuel mileage and improve ride quality led to the introduction of composite rotors. Composite rotors have a stamped steel center hat attached to a cast iron rotor and are about 20 percent lighter than conventional one-piece cast iron rotors. The downside to these rotors is that they must be properly supported when resurfacing, or they can flex and cause surface finish problems and excessive runout.

Changes in disc brake pad material have affected the brake rotor friction surface. The semi-metallic compound pads that first replaced asbestos were noisy and harder on rotors, with a subsequent decrease in rotor life. The newer semi-metallics, along with the latest non-asbestos organic and ceramic compounds, require a smooth surface finish, meaning that attention must be paid to the condition of the lathe bits and the feed rate of the lathe. Sanding with fine sandpaper after turning is usually required, too.

Regardless of the complexities that have been added to brake rotor service, the goal remains the same: to ensure that lateral rotor runout, rotor thickness variation (parallelism) and rotor surface finish are within the manufacturer's specifications. Today's technician has several ways to achieve this goal, but before we discuss how he or she does that, the rotor must be thoroughly inspected and measured.

Inspection

Visually inspect the rotor for cracks, scoring, heat checks, hard spots and lining deposits. If there are small heat checks and surface cracks, the rotor can be reused providing they are removed by resurfacing. However, large cracks are cause for rotor replacement. Hard spots can cause uneven wear and pedal pulsation and also are a reason for rotor replacement, because resurfacing seldom removes the entire hard spot.

If the rotor passes the appearance test, measure the rotor thickness and thickness variation using a disc brake micrometer. Unlike a standard micrometer that uses a flat surface on the anvil and movable spindle tips, a disc brake micrometer uses pointed tips. The reason for this is so the instrument can fit into the grooves of scored rotors to accurately measure the thickness.

Measure the rotor thickness at eight equidistant points around the rotor, at the inside, middle and outside areas of the brake pad contact surface. Most rotors come with the 'discard' or 'machine to' dimension cast into them; if this cannot be found or is illegible, consult the vehicle service manual for the specification. A rotor should be replaced if it is worn below the 'discard' thickness or if it cannot be resurfaced without exceeding the 'machine to' dimension.

Thickness variation is much harder to measure, because in many cases, anything exceeding 0.0003 to 0.0005 inch is beyond specification. Always consult the vehicle service manual for the exact specification. Although this a very small amount, any more can cause a pedal pulsation.

Thickness variation usually is caused by excessive lateral runout (wobble). As the rotor turns, the brake pads wear the high spots on each side of the rotor, gradually wearing the rotor until those areas are thinner than the rest. If there is excessive lateral runout at the time of the last brake job or from when the vehicle was new, pedal pulsation caused by thickness variation may not develop for 3,000 to 7,000 miles down the road.

One way to maintain rotor runout within specifications when using a bench lathe, is to use a tapered shim that fits over the wheel studs and between the hub and rotor. These shims, or runout correction plates, have been approved by General Motors for use in their dealerships.

After measuring the brake rotor thickness, measure the runout using a dial indicator. If the vehicle is equipped with adjustable tapered roller bearings, eliminate all the wheel bearing end-play with the wheel spindle nut before checking the runout. Secure non-integral rotors to the hub using the lug nuts installed backwards. Mount the dial indicator on the suspension at a convenient place so that the indicator stylus contacts the rotor face in the middle of the brake pad contact area. Set the dial to zero, and check the total indicator reading while turning the rotor one full revolution. Compare the reading with specifications.

Runout exceeding 0.003 inch can cause pedal pulsation. Excessive lateral runout can be caused by improper lug nut torquing, a poor previous resurfacing job, rust buildup between the hub and rotor or manufacturing defects.

To cut or not to cut??

You have now determined if the rotor requires replacement or if resurfacing is necessary to bring the rotor within specifications. But what if all measurements were within specification, the friction surface is smooth and the vehicle had no brake problems other than worn linings? Should you still resurface the rotor? Unlike the old days, today the prevailing wisdom is no, for several reasons.

Resurfacing the rotor unnecessarily removes material and makes the rotor thinner, lessening its ability to absorb and dissipate heat and shortening the rotor's useable lifespan. Improper machining also can create problems. For instance, if a non-integral rotor is not setup properly on a bench lathe, an excessive lateral runout condition that did not previously exist can be created when it is reinstalled on the hub. Improper resurfacing also can create a friction surface that is too rough, causing brake noise, premature pad wear and a hard pedal condition.

Many of the OEMs have issued bulletins in the last few years providing guidelines for brake rotor servicing. In these bulletins, they've indicated that brake rotors should not be resurfaced during routine brake pad replacement. Most also recommend that new rotors not be resurfaced.

Finally, if the rotor's surface condition is acceptable and all dimensions except runout were within specification, try changing the position of the rotor on the hub and rechecking the runout. A change in position may bring runout within allowances.

If inspection and measurement determined that resurfacing is necessary, there are two alternatives: the traditional bench lathe or an on-car brake lathe. As stated previously, a traditional bench lathe is fine for resurfacing rotors with integral hubs and tapered roller bearings. However, a bench lathe requires more effort for turning non-integral rotors or excessive lateral runout can be created. After measuring runout with the rotor on the hub, the runout also must be measured with the dial indicator when the rotor is mounted on the lathe. If the runout isn't in the same place and/or the same amount, the rotor should be shimmed until the runout is duplicated.

Another way to use a bench lathe and maintain lateral runout within specifications is to use tapered shims. After the rotor is resurfaced, it is remounted on the hub, and runout is checked with a dial indicator. If runout is excessive, the high spot is marked and the rotor is removed. The tapered shim is then installed on the hub with the thickest part opposite the high spot. When the rotor is reinstalled, runout should be within specification.

When using a bench lathe to resurface composite rotors, special adapters must be used to support the steel center section, or the rotor can flex and cause runout and surface finish problems. Also, if an aftermarket cast replacement rotor is used to replace a composite rotor, the rotors on both sides of the vehicle should be replaced, regardless of the other rotor's condition.

For a bench lathe with a fixed 150-rpm spindle speed, a rough cut of 0.005 inch can be made at 0.006 to 0.010 inch cross feed per revolution. A finish cut of 0.002 inch should be made at no more than 0.002 inch cross feed per revolution.

On-car brake lathes fall into two categories - caliper-mounted lathes and hub-mounted lathes. Both types are ideal for resurfacing rotors on vehicles where the rotor is difficult to remove.

Caliper-mounted lathes were the first type of on-car lathes widely available. They are two-piece units with one part rotating the rotor and the other part being the cutting mechanism, which is attached to the steering knuckle. They usually require many adapters due to the variety of steering knuckle designs, and they can be time-consuming to set up.

Hub-mounted lathes combine the rotor drive device and cutting mechanism in a single unit. These lathes machine the rotor so that it is perpendicular to the wheel's axis of rotation, thereby minimizing runout. Most require only five or six adapters to allow hub attachment on most cars and light trucks. The latest design hub-mounted lathes can resurface a rotor in approximately 10 minutes, from the time the machine is attached, to the finished rotor. Some offer automatic runout compensation, which further simplifies the setup process.

Regardless of the type of lathe that is used, the finished surface of the rotor must be very smooth: between 20 and 70 micro-inches. After the rotor has been machined, sand the friction surface with 120- to 150-grit sandpaper, mounted on a sanding block, while the rotor turns on the lathe. Apply a non-directional finish using the sandpaper, until the machined finish that was created by the cutting bit begins to disappear, about one minute per side.

After resurfacing now that you have a brake rotor that is within specification and ready to be put back into service, attention to detail during the remainder of the brake job will help to ensure that the rotor stays true and the brakes perform properly.

When rotor resurfacing is completed, wash the rotor with soap and water and wipe it off with a clean shop towel. Brake cleaning solvent may not remove all of the fine particles left over from the machining process, and these can become imbedded in the new pads and cause brake noise. Always make sure that the inside of a non-integral rotor and the hub flange are clean and free of corrosion, dirt or burrs that could cause runout when reassembled.

Although disc brake noise is usually thought to be caused by the disc brake pad against the rotor's friction surface, in reality more noise is caused by the brake pad not being insulated properly from the caliper or caliper piston. Always make sure that all required disc brake pad shims, clips and anti-rattle springs are installed properly. In addition, old disc brake pad shims should not be reused and should be replaced along with the brake pads.

Make sure all other caliper hardware like slide pins and bushings are in good condition and replace any questionable parts. Clean and lubricate caliper slides and shoe pads with moly-based high-temperature brake grease.

Torque the lug nuts in a star pattern using a torque wrench or torque-limiting socket. Tighten the lug nuts in two steps, first to half of the torque specification and then to the full torque specification. Break-in the new pads by making about 10 moderate stops from 30 mph, waiting about a minute between brake applications, and avoiding severe braking for several hundred miles.

Like most other systems on modern vehicles, servicing disc brakes on today's cars and trucks can be more challenging than it was on their predecessors. To prevent comebacks caused by noise and pedal pulsation, rotors must be measured properly and machined accurately. To achieve this, you may have to make an investment in time and equipment, but your reward will be satisfied customers and their repeat business.

Electronic Sensors and the Transmission

Today’s electronic transmissions use sensors, solenoids and relays to regulate the operation of the clutches, gears and torque converter. On applications where these functions have not been integrated into the powertrain control module (PCM), there’s a separate transmission control module (TCM) to oversee the operation of the transmission - and that’s the focus of this article: how TCMs and PCMs interact.

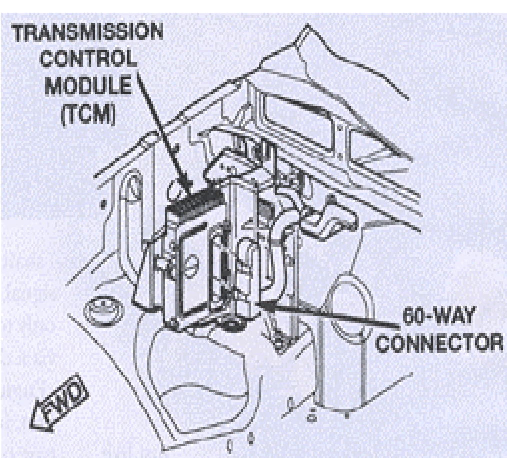
Just like the PCM, the TCM needs accurate information to do its job properly. If the transmission computer receives bad information from the transmission’s own internal sensors or bad inputs from the PCM or other engine sensors, it will have an adverse effect on how the transmission operates. It may not shift smoothly. It may shift at the wrong rpm. It may even go into a "limp-in" mode and remain frozen in second or third gear.

Essential Information
Electronic transmissions are getting smarter all the time. Most of the current generation units have fully adaptive control systems that "learn" the best shift points based on real-time sensor inputs and feedback. The transmission computer adapts the shift strategy to compensate for changes in engine performance and wear in the transmission friction elements in the clutches. By making subtle changes to the shift points and engagement, the computer tries to maintain consistent shift quality.

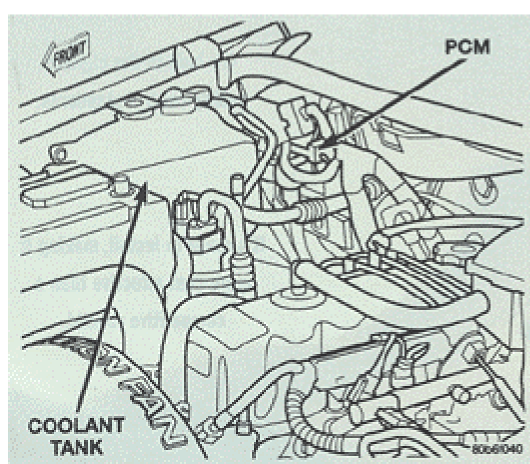
The transmission computer monitors what’s happening inside the transmission with various speed and gear range sensors that tell it if the gears are shifting correctly and at what speeds. But to pick the shift points, it needs certain inputs from the engine and PCM. The transmission computer needs to know how fast the vehicle is traveling. This information is provided by the vehicle speed sensor. It also needs to know engine speed (rpm) and load.

On some applications, the rpm signal is hard-wired directly to the transmission computer as well as the PCM. There’s a dedicated circuit between the crankshaft position sensor and TCM to supply the rpm signal. On other applications, the rpm signal goes only to the PCM and the PCM forwards it to the TCM via a data bus circuit.

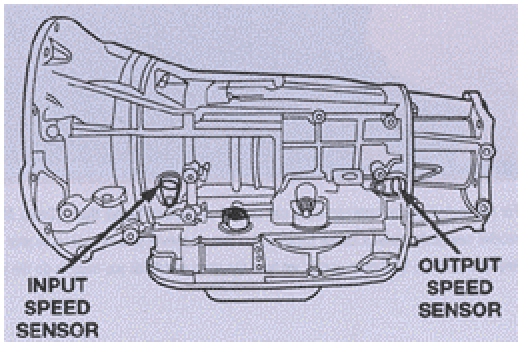
Engine load can be determined from throttle position, intake vacuum and airflow. Depending on what type of fuel injection system is used (speed density or airflow), engine load inputs may come from the throttle position sensor (TPS), manifold absolute pressure sensor (MAP) and/or a vane airflow sensor (VAF) or mass airflow sensor (MAF). As with the rpm signal, the information may be shared directly with the transmission computer or it may go through the PCM and forwarded to the TCM over the data bus.



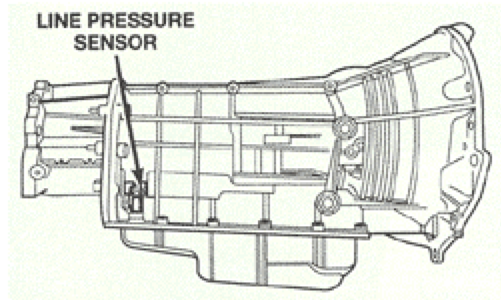
Location of the Transmission Control Module on the Chrysler 45RFE electronic automatic transmission.



If the TPS signal doesn't correspond to other sensor inputs that can be used to measure engine load, the PCM, located near the coolant tank, may set a fault code.



Locating the Input and Output Speed Sensors on Chrysler's 45RFE unit.



Immediate shutdown mode, where the TCM de-energizes the transmission control relay and locks the transmission in gear, is usually caused by an internal transmission solenoid, sensor or pressure switch problem.

Effects of ATF Oil Temperature
Regardless of how the information is generated and how it gets there, the transmission computer juggles the various inputs to come up with the best shift points. But because automatic transmissions use hydraulics to operate the clutches and gear changes, oil temperature is another factor that needs to be considered to maintain consistent shift quality. An ATF oil temperature sensor inside the transmission provides information the TCM needs to adjust shift pressures when the ATF is cold and when it is hot. If the thermistor that provides the oil temperature input isn't working, the TCM can go to the PCM for help and estimate oil temperature based on engine coolant temperature and how long the vehicle has been running.

For example, on Chrysler 45RFE electronic automatics (which are used in Jeep Grand Cherokees and are similar to Chrysler's 41TE and 42LE transmissions), the TCM can look at the engine coolant temperature sensor reading when the vehicle is first started and use that as a reference point for estimating the ATF oil temperature. Once this has been done, the TCM updates the estimated transmission oil temperature as the vehicle is being driven based on torque converter slip speed, vehicle speed, gear position and engine coolant temperature. The estimated oil temperature will be pretty close to the real oil temperature if the vehicle is driven normally and there are no other problems. But if the transmission is overfilled with fluid, the transmission oil cooler is restricted, the engine is running hot, or if the vehicle is driven aggressively in low gear, the TCM will underestimate the oil temperature causing the transmission to shift at the wrong points.

Chrysler's 45RFE uses several "shift schedules" that are based on ATF oil temperature. There's an "extreme cold" schedule when the oil temperature is below -16° F that allows Park, Neutral, Reverse, first and third gears only. If the oil temperature is between -12° and 10° F, it uses the "super cold" shift schedule that delays 2-3 and 3-4 upshifts, and provides an earlier 4-3 and 3-2 coastdown shifts. High speed 4-2, 3-2 and 2-1 kickdown shifts are prevented in this mode. When the ATF is between 10° and 36° F, the "cold" schedule takes over and the transmission shifts at higher throttle openings and high speed 4-2, 3-2 and 2-1 kickdown shifts are still prevented. Also, there is no torque converter clutch lockup in the cold, super cold or extreme cold ranges.

Once the ATF is above 40°, the TCM goes to the "warm" schedule, which allows normal upshifts, kickdowns and coastdowns - but still not torque converter lockup. When the ATF reaches 80° F, the TCM changes to the "hot/normal" mode and begins to engage the torque converter when vehicle speed is above about 22 mph.

If the ATF gets too hot (above 240° F), or the engine starts to overheat (coolant above 244° F), the TCM will employ an "overheat" schedule that delays 2-3 and 3-4 upshifts and changes the torque converter lockup points. If the ATF gets really hot (above 260° F), the TCM goes into a "super overheat" mode which further delays 2-3 and 3-4 upshifts and prevents the torque converter clutch from unlocking above 22 mph unless the throttle angle is less than 4° or a wide open throttle 2-1 kickdown is made.

The point here is that the temperature of the ATF as well as the engine coolant can have a major effect on how an electronic transmission operates. So too can the inputs from the throttle position sensor, crankshaft position sensor, MAP sensor and other engine sensors.

Chrysler says its 45RFE transmission can be put into an overheat or superheat shift schedule by anything that causes the engine to overheat, by aggressive driving in low gear, by towing a trailer in the "OD" (overdrive) position (using "3" is recommended if frequent gear shifts occur), by driving in heavy stop-and-go city traffic, or by an engine that is idling too fast (stuck AIS motor).

If the engine coolant temperature stays too low too long (due to an open thermostat or faulty coolant sensor), the TCM may go into a cold mode and prevent the torque converter clutch from locking up.

Effects of Bad Engine Sensor Inputs
Because the transmission needs to know engine speed and load as well as vehicle speed to pick the right shift points, a bad sensor input or loss of a signal can create real problems for the transmission computer.

The throttle position sensor signal takes the place of the throttle kickdown linkage on older mechanical automatics. So if the TPS is reading high or low, or has a dead spot, it can affect transmission kickdown shifts when accelerating, as well as normal upshifts and downshifts, too. If the TCM can't get a good TPS signal, it may substitute a "calculated" throttle angle provided by the PCM over the data bus. Or, if this signal isn't available, it may substitute a fixed value for the TPS signal. This will obviously affect the way it shifts (transmission typically hunts for shift points) but not necessarily cause it to go into a limp-in mode.

A faulty throttle position sensor won't always set a fault code. The PCM has to be smart enough to figure out when the TPS is working properly and when it isn't. It's own diagnostic strategies may compare the TPS signal against engine rpm, MAP signal and/or airflow to determine if the TPS signal makes sense. If the TPS signal doesn't correspond to other sensor inputs that can be used to measure engine load, the PCM may set a fault code. Then again, it might not. It all depends on the self-diagnostic strategy, how sensitive it is to faults and how easily the PCM can detect problems.

Limp-In Modes
Under certain conditions, which may include the loss of one or more vital inputs to the TCM, the transmission will go into some kind of limp-in or "default" mode. On Chrysler's 45RFE transmission, there are three different default modes:

- Immediate shutdown mode - The TCM de-energizes the transmission control relay and locks the transmission in third gear when the shift lever is in the Drive position, or second gear if the gear shift is in "2" or "L" position. The causes here are usually an internal transmission solenoid, sensor or pressure switch problem.
- Orderly shutdown mode - If the problem is less serious, the TCM will remain in whatever gear it is in but default into third gear and stay there as soon as the vehicle slows down (or second gear if it is in "2" or "L").
- Logical shutdown with recovery - The TCM operates the transmission at a steady preset pressure value and uses first and third gears only while in Drive. The transmission will resume normal operation if the problem goes away.

The point here is if the transmission is in a limp-in or default mode, something is wrong. It may be an internal transmission problem, an engine sensor problem, a data bus problem or even a problem within the TCM or PCM modules.

Diagnostic Trouble Codes

Like PCMs, TCMs have the ability to self-diagnose faults and set diagnostic trouble codes that can be read with a scan tool. So if the Malfunction Indicator Lamp (MIL) is on and the transmission isn't operating properly, the fault may be in the transmission - or it may be in the engine. The only way to find out is to pull the code(s) to see what's going on.

It's not unusual to blame some engine driveability problems on the transmission and vice versa. A torque converter that locks up prematurely or fails to release quickly enough can cause a driveline shudder that may feel like an engine misfire or vibration. If the torque converter fails to release at all, it can cause the engine to buck and stall when coming to a stop.

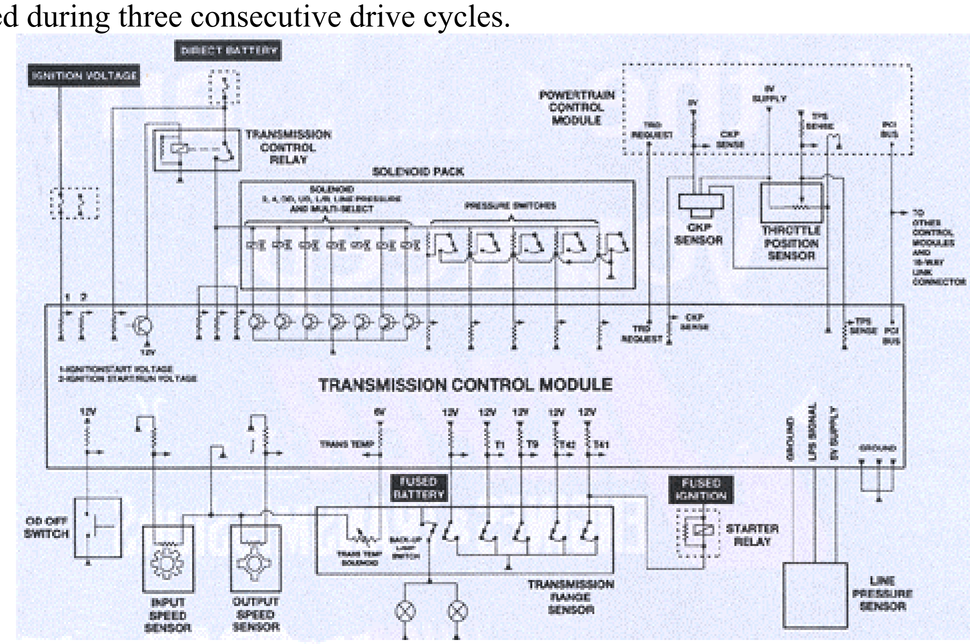
Any time you encounter a problem with an electronic automatic or find a transmission code, make sure the engine is running properly and there are no engine codes that could affect the operation of the transmission. In other words, take care of any engine problems first before attempting to diagnose a transmission problem.

If a vehicle has a data bus communication problem between the TCM and PCM, you probably won't be able to access any transmission codes until the wiring problem is fixed. Possible causes include an open or short to the ground or battery in the PCI bus circuit, or an internal failure of any module or component that is attached to the bus.

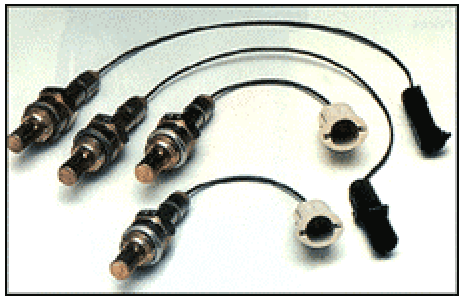
The data bus is monitored any time the ignition key is on. If no messages are received from the PCM for 10 or more seconds, it tells the TCM something is wrong and it sets a data bus code. On Chrysler's 45RFE, a data bus problem (codes P1716 or P1719) can cause the transmission to shift poorly, delay 3-4 shifts and prevent torque converter lockup.

If the transmission can find an engine speed signal from the crankshaft position sensor or PCM, the transmission can be forced into the limp-in mode. The problem should set a crank sensor circuit fault code and turn on the MIL. Possible causes include an open or short in the crank sensor circuit, a TCM connector problem, an open or short in the crank sensor ground circuit, or an internal fault in the TCM or PCM.

On OBD II applications, various transmission codes are included in the "generic" list of OBD II codes. If the transmission computer detects a problem that may affect emissions, it will send a request over the data bus to the engine computer to turn on the MIL lamp. A code will be set in the TCM and remain there until it is cleared or no fault is detected during 40 consecutive drive cycles. The MIL may go out but leave the code in memory if no fault is detected during three consecutive drive cycles.



If a vehicle has a data bus communication problem between the TCM and PCm, you probably won't be able to access any transmission codes until the wiring problem is fixed.



Seven Steps for Troubleshooting EATs
The recommended procedure for troubleshooting an electronic automatic transmission (EAT) problem involves seven steps:

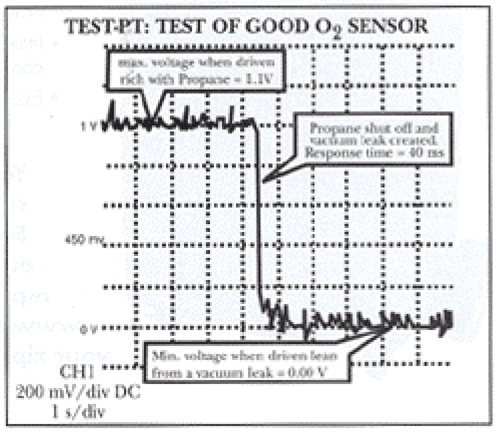
1. Verify the complaint. Is the transmission really shifting improperly, shuddering, slipping, etc.?
2. Verify any related symptoms. Is the engine overheating, are there engine fault codes or other driveability problems?
3. Analyze the symptoms and when they occur. Does the complaint only occur when hot, cold, driving at certain speeds, etc.?
4. Check for any OEM technical service bulletins that might apply to the problem.
5. Isolate the fault. Use the trouble codes and diagnostic charts to narrow down the possibilities. Is the problem inside or outside the transmission. Is it hydraulic, mechanical or electronic?
6. Repair the fault. Replace the faulty component, replace the transmission or repair the wiring fault.
7. Verify the repair. Did you fix the problem?

O2 Sensors: Maintaining Peak Engine Performance
Impact on the Fuel Feedback Control Loop

Diagnosing oxygen sensor-related driveability problems doesn't have to be difficult if you understand how the O2 sensor operates within the emissions system.
You should already know that the O2 sensor monitors the fuel mixture so the engine computer can adjust the air/fuel ratio to maintain the lowest possible emissions and best fuel economy. But do you understand the process?
It's actually quite simple. The O2 sensor is designed to react to unburned oxygen in the exhaust. The sensor generates a small voltage signal (usually less than 1 volt) that increases when the air/fuel mixture goes rich, and drops when the air/fuel mixture goes lean. It acts like a rich/lean switch that signals the computer every time the fuel mixture changes, which is constantly.
The way the computer maintains a balanced fuel mixture is by doing the opposite of what the O2 sensor reads. If the O2 sensor reads rich (too much fuel), the computer shortens the on-time of each injector pulse to reduce the amount of fuel being squirted into the cylinder. This makes the mixture go lean. As soon as the O2 sensor

detects this and gives a lean reading (not enough fuel), the computer reacts and increases the on-time of each injector pulse to add more fuel. This back-and-forth balancing act creates an average mixture that is pretty close to ideal. This is the "fuel feedback control loop" that allows today's vehicles to maintain extremely low emission levels, and the O2 sensor is the key sensor in this loop.
The computer uses other sensor inputs, too, like those from the coolant sensor, throttle position sensor, manifold absolute pressure sensor, airflow sensor, etc. to further refine the air/fuel radio as needed to suit changing operating conditions. But the O2 sensor provides the main input that determines what happens to the fuel mixture. So if the O2 sensor isn't reading right, it screws up everything.

Knowing What's Bad



Typically, a bad O2 sensor will read low (lean), which causes the engine to run too rich, pollute too much and use too much gas. A low reading can be caused by several things: old age, contamination, a bad wiring connection, or an ignition or compression problem in the engine.
Also, as an O2 sensor ages, it doesn't react as quickly as it once did. The increased lag time makes the sensor sluggish and prevents the engine from keeping the air/fuel mixture in close balance. If the engine burns oil or develops an internal coolant leak, the sensor element may become contaminated, causing the sensor to fail.
Keep in mind that O2 sensors need to be hot (617° F to 662° F) to produce a voltage signal. It may take a few minutes for the exhaust to heat up the sensor, so most O2 sensors in newer vehicles have a built-in electrical heater circuit to get the sensor up to temperature as quickly as possible. These are usually three-wire and four-wire O2 sensors. The single- and two-wire O2 sensors are unheated.
If the heater circuit fails, it won't affect the operation of the O2 sensor once the exhaust gets hot. But it will delay the computer from going into closed loop, which may cause a vehicle to fail an emissions test.

Common Diagnosis

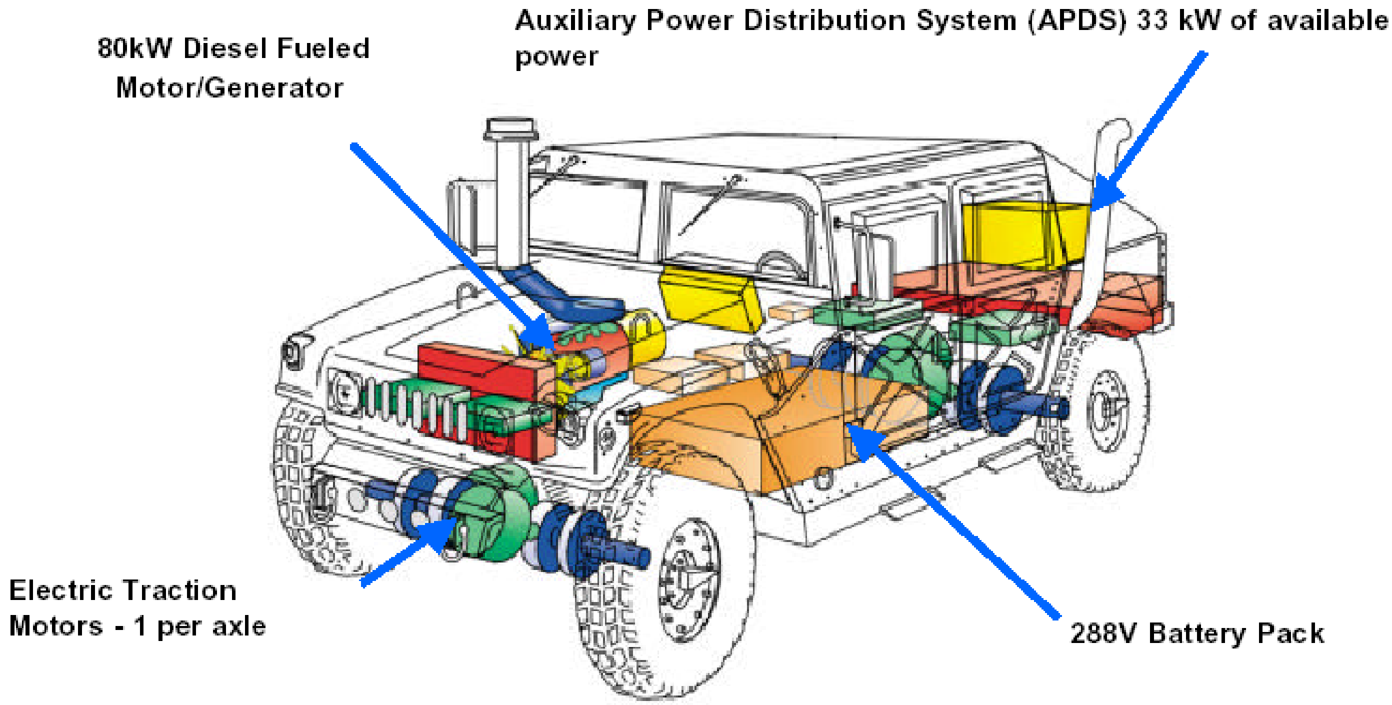
O2 sensors can be diagnosed a variety of ways, most of which require special equipment. A scan tool or code reader is required to pull O2 codes from most newer vehicles, though manual "flash codes" are available on older vehicles. If an O2 sensor problem is suspected, the sensor's response and voltage output can be monitored with a scan tool, a voltmeter or digital oscilloscope. If the tests confirm the O2 sensor is dead or sluggish, replacement is the only repair option. There is no way to "clean" or "rejuvenate" a bad O2 sensor.
Replacement sensors must be the same basic type as the original (heated or unheated) and have the same performance characteristics and heater wattage requirements. Installing the wrong O2 sensor could affect engine performance and possibly damage the heater control circuit in the engine computer. So make sure you follow the O2 sensor supplier's replacement listings.
Don't go by appearance alone. Some replacement O2 sensors have an OEM-type wiring connection and require no modifications to install. Others (typically the universal type O2 sensors) require splicing the sensor wires into the original connector harness.

Troubleshooting Tip
Because the sensor reacts to oxygen in the exhaust and not fuel, any engine problem that allows unburned air to pass through the cylinders will also trick an O2 sensor into reading lean. A misfiring spark plug or a leaky exhaust valve - even a leak in the exhaust manifold gasket - may allow enough air into the exhaust to screw up the sensor readings. It won't damage the sensor, but it will create a rich running condition that hurts emissions and fuel economy.

Replacement Recommendations
To maintain peak engine performance, there's no need to wait until the sensor fails to replace it. Some experts now recommend replacing O2 sensors at specific mileage intervals for preventive maintenance. The recommended interval for unheated one- or two-wire O2 sensors on 1976 through early 1990s applications is every 30,000 to 50,000 miles. Heated three- and four-wire O2 sensors on mid-1980s through mid-1990s applications can be changed every 60,000 miles. And on 1996 and newer OBD II vehicles, the recommended replacement interval is 100,000 miles.

Keeping Count
Four cylinder and straight six-cylinder engines typically have only one O2 sensor in the exhaust manifold. With V6 and V8 engines, there is one O2 sensor for each cylinder bank, or a total of two (one in each exhaust manifold).
On 1996 and newer vehicles with OBD II, there is also one or more additional O2 sensors mounted after the catalytic converter to monitor the efficiency of the converter. If a vehicle has dual exhausts, there will be one downstream O2 sensor for each side. So a V8 vehicle with dual exhausts will usually have a total of four O2 sensors.

Did you know…
...that over the past 20 years of computer-controlled engine management systems, thousands of diagnostic strategies have been developed regarding the monitoring of the fuel management system? In some systems, for example, the O2 sensor exerts a major (perhaps 90%) control on fuel control functions. In other systems, the O2 sensor merely trims the air/fuel mixture and, therefore, is responsible for only 10% of the system's fuel control function.



The Hybrid Electric HMMWV is derived when the traditional mechanical drive train (engine, transmission and transfer case) is removed from a conventional HMMWV and replaced with a hybrid electric drive train. The hybrid electric drive train consists of a motor-generator set, two drive motors, and a battery pack. The Hybrid drive train is in a series configuration, where the motor-generator set does not have a direct mechanical linkage to the wheels. Army interest in the HE HMMWV is predominantly in the areas of fuel consumption and logistical footprint reduction. Other areas of interest are the decreased thermal and acoustic signatures as well as the availability of silent watch and silent mobility. The target for the HE program is to achieve the standard HMMWV mobility and payload (5,100 pounds) while also providing silent watch, silent mobility and the ability to produce a minimum of 33 kilowatts of continuous power. Four technology demonstrator vehicles are currently under contract, to be delivered in May 2002 for Government testing. Results of this testing will be used to build documentation for a competitive source selection in 2003. The HE HMMWV will be cut into production in FY05.

HYBRID ELECTRIC HMMWV
80kW Diesel Fueled
Motor/Generator
Electric Traction
Motors - 1 per axle
Auxiliary Power Distribution System (APDS) 33 kW of available
power
288V Battery Pack
GOAL: Meet / Exceed Performance & Operational
Capabilities of Conventional HMMWV
Projected Performance Anticipated Benefits
• 30% Reduction in Fuel Consumption
• 33 kW of Continuous Useable Power
• 12-Miles Silent Mobility (limited)
• 6 Hours of Silent Watch (limited)

• Footprint Reduction
• Silent Watch
• Silent Mobility
• Increased Survivability

Potential Applications

• Power for Tactical Operation Centers / Shelters
• Power Solid State Lasers / Non-Lethal Weapons
• Scout Mission
• Power Radar Systems

Enablers

• Technology – Batteries / Traction Motors
• Small US Manufactured Diesel Engine
• Auxiliary Power Distribution System
• Change in Force Structure

CESE Maintenance, Repair and Operation Builder and Military Skills Video Tapes

The following listed videotapes are available from the Seabee Logistics Center, Code 43, 1000 23rd Avenue, Port Hueneme, CA. 93043. These tapes are from various manufacturer's, such as Bendix, Caterpillar, Champion, Chrysler, Detroit Diesel, Ford, General Motors, and John Deere and are VHS format only. Request must be submitted by the Maintenance Supervisor and must show their, name, rank/rate, command, address and DSN telephone number. Incomplete requests will not be shipped. Due to the limited number of videotapes of a specific title, loan of videotapes are limited to 30 calendar days.
Request will be filled on a "first come, first serve basis". You may request up to eight videotapes, in priority sequence on the request form; we will send you up to four videotapes if available. If none are available, we will notify you. For an order form, visit our Video Library Intranet Site at https://ncf.navy.mil/ncbc/pdfs/video_library.pdf For questions concerning these videotapes, contact CMCS (SCW) Hill at DSN 551-3085 or COM. 805-982-3085.

Recent Recall Information

NHTSA CAMPAIGN ID Number: **02V266000**
Component: BRAKES:HYDRAULIC:PEDAL
Manufacturer: FORD MOTOR COMPANY
Year: 2000
Make: FORD
Model: TAURUS , SABLE
Recall Date: 10/04/2002
Type of Report: Vehicle
Potential Number of Units Affected: 369614
Manufactured: 05/1999 - 09/2001
Defect Summary:
CERTAIN PASSENGER VEHICLES EQUIPPED WITH ADJUSTABLE PADELS ARE BEING RECALLED IN ORDER TO ADJUST THE BRAKE AND ACCELERATOR PEDALS TO A MINIMUM OF 50 MM OF LATERAL SEPARATION. SIMULTANEOUS APPLICATION OF BOTH THE BRAKE AND ACCELERATOR PEDALS COULD RESULT IN AN INCREASE IN ENGINE RPM.
Consequence Summary:

THIS COULD RESULT IN A CUSTOMER EXPERIENCING AN "UNINTENDED VEHICLE SPEED INCREASE" OR A PERCEIVED "UNABLE TO STOP" CONDITION.

Corrective Summary:

OWNERS WILL BE INSTRUCTED AS TO THE PROPER WAY TO SET THE POSITION OF THE PEDALS AND TO TAKE THEIR VEHICLES TO A DEALER TO HAVE THE SPACING BETWEEN THE BRAKE AND ACCELERATOR PEDALS MEASURED. IF THE SPACING IS FOUND TO BE LESS THAN 50 MM, THE DEALER WILL ADJUST THE PEDALS TO INCREASE THE DISTANCE BETWEEN THEM TO GREATER THAN 50 MM. OWNER NOTIFICATION IS EXPECTED TO BEGIN DURING NOVEMBER 2002. OWNERS WHO DO NOT RECEIVE THE FREE REMEDY WITHIN A REASONABLE TIME SHOULD CONTACT FORD AT 1-866-436-7332.

NHTSA CAMPAIGN ID Number: 02V267000

Component: ELECTRICAL SYSTEM:BATTERY:CABLE

Manufacturer: GENERAL MOTORS CORP.

Year: 2003

Make: CHEVROLET TRUCK

Model: KODIAK , TOPKICK

Recall Date: 10/04/2002

Type of Report: Vehicle

Potential Number of Units Affected: 276

Manufactured: 08/2001 - 07/2002

Defect Summary:

CERTAIN MEDIUM DUTY TRUCKS EQUIPPED WITH THE OPTIONAL CATERPILLAR DIESEL ENGINE (LG5) OPTION WERE BUILT WITH A MISROUTED BATTERY CABLE THAT COULD COME IN CONTACT WITH THE EXHAUST PIPE. THE CONDUIT AND THE NYLON CABLE COATING COULD DEGRADE TO THE POINT WHERE THE COPPER WIRE STRANDS OF THE CABLE ARE EXPOSED.

Consequence Summary:

IF THE CABLE STRANDS CONTACTED THE EXHAUST PIPE A SHORT CIRCUIT COULD CAUSE THE BATTERY CABLE COATINGS TO IGNITE AND POSSIBLY LEAD TO AN ENGINE COMPARTMENT FIRE.

Corrective Summary:

DEALERS WILL INSPECT THE BATTERY CABLE FOR PROPER ROUTING AND REROUTE THE CABLE IF NECESSARY. OWNER NOTIFICATION IS EXPECTED TO BEGIN DURING OCTOBER 2002. OWNERS WHO TAKE THEIR VEHICLES TO AN AUTHORIZED DEALER ON AN AGREED UPON SERVICE DATE AND DO NOT RECEIVE THE FREE REMEDY WITHIN A REASONABLE TIME SHOULD CONTACT CHEVROLET AT 1-800-222-1020 OR GMC AT 1-800-462-8782.

NHTSA CAMPAIGN ID Number: 02V269000

Component: EMERGENCY PARKING BRAKE

Manufacturer: MACK TRUCKS, INCORPORATED

Year: 2002

Make: MACK

Model: CH

Recall Date: 10/04/2002

Type of Report: Vehicle

Potential Number of Units Affected: 557

Defect Summary:

CERTAIN CLASS 8 CHASSIS FAIL TO COMPLY WITH REQUIREMENTS OF FEDERAL MOTOR VEHICLE SAFETY STANDARD NO. 121, "AIR BRAKE SYSTEMS." THE INSTALLATION OF THE ADDITIONAL AXLE(S), RAISES THE GVW CAPABILITY OF THE VEHICLE AND THEREFORE REQUIRES AN INCREASE IN THE PARKING BRAKE PERFORMANCE TO HOLD ON A 20% GRADE IN ORDER TO MEET THE REQUIREMENTS OF THE STANDARD.

Consequence Summary:

SORRY, CONSEQUENCE SUMMARY IS NOT AVAILABLE. FOR MORE INFORMATION CONTACT YOUR LOCAL DEALER.

Corrective Summary:

MACK HAS NOT YET PROVIDED A REMEDY OR AN OWNER NOTIFICATION SCHEDULE FOR THIS CAMPAIGN. OWNERS WHO TAKE THEIR VEHICLES TO AN AUTHORIZED DEALER ON AN AGREED UPON SERVICE DATE AND DO NOT RECEIVE THE FREE REMEDY WITHIN A REASONABLE TIME SHOULD CONTACT MACK AT 1-610-709-3337.

Suggestions???

You can help to improve this maintenance bulletin. If you have any topic(s) or ideas for inclusion into any future maintenance bulletins, please contact CMCS(SCW) Paul Hill at COMM: (805)982-3085 DSN: 551-3085 or by e-mail hillpm@cbchue.navfac.navy.mil